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Long Term Quality of Life Following Vestibular Schwannoma Excision via the Translabyrinthine Approach

Short Running Head: Quality of Life after Vestibular Schwannoma surgery

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Introduction

Vestibular schwannomas, commonly known as acoustic neuromas, are a benign tumour of the eighth cranial nerve and the commonest lesion of the cerebellopontine angle. With improved access to magnetic resonance imaging (MRI), vestibular schwannomas are increasingly diagnosed at an early stage. Whilst surgery remains the mainstay of treatment for large tumours, there are several management options for small and medium-sized tumours. These include conservative management (so-called 'wait and rescan'), radiation treatment (gamma knife radiosurgery or stereotactic radiotherapy), or microsurgical excision (with a variety of surgical approaches). The possibility of hearing preservation, new radiation dosing regimens, subtotal surgical excision and combination therapies have further complicated decision making in this already complex field. For this reason, there has been increasing interest in quality of life (QOL) outcomes in patients with vestibular schwannomas, though it is not yet clear how QOL outcomes can be used in the decision-making process.[1-3] As some of the impact on QOL undoubtedly comes from the diagnosis itself, rather than the treatment, adequate psychosocial support for vestibular schwannoma patients is critical.[4] For patients undergoing treatment, counselling must give some realistic expectation of long-term outcome, whichever treatment modality is chosen. The aim of this study was to examine a large series of patients undergoing translabyrinthine surgery under a single surgeon and report long term post-operative QOL results as well as more disease-specific outcomes.

Materials and Methods

Five hundred consecutive patients who had translabyrinthine surgery for vestibular schwannoma under the care of the senior author (RTR) either as sole surgeon or working as part of the joint Neuro-otology /Skull Base team at Manchester Royal Infirmary and Salford Royal Hospital were identified. The cases were taken from a larger database of approximately 2000 vestibular schwannomas managed between 1978 and 2009, including over 1200 operated tumours. The series under study had a minimum follow up of 5 years. Patients with neurofibromatosis type 2 and those who underwent alternative surgical approaches (middle fossa, retrosigmoid, suboccipital) were excluded. Subjects were sent two surveys by post; the 36 item Short Form Health Survey (SF-36, Medical Outcomes Trust), and an additional generic post-operative quality of life (QOL) survey (hereon referred to as QOL-2) devised by the authors to assess the more subjective elements of outcome from surgery (appendix 1). Items assessed with the QOL-2 survey included pre- and post-operative symptoms (self-graded as 'mild', 'moderate' or 'severe'), and subjective assessment using 5-point Likert scales to measure overall quality of life, overall health and mood as well as post-operative ability to work, drive and perform sports/hobbies. Demographic data collected from the

database included patient gender and age, year of surgery and tumour size (measured as the maximum intracranial transverse diameter of the tumour in cm on the pre-operative MRI scan). Purely intra-canalicular tumours were treated as a separate category, with other tumours categorised into groups according to the tumour size (see results).

Scoring of the SF-36 surveys was performed according to the manual as previously described.[5] Scores generated ranged from 0 (worst possible QOL) to 100 (best possible QOL). Continuous variables were described using means with standard deviations (SD) when their distribution was found to be normal, and medians with interquartile ranges (IQR) when their distribution was skewed. Categorical variables were described using frequency counts and percentages. Statistical analysis was performed using IBM SPSS for Windows version 23. Statistical tests were performed 2-sided and the p values obtained were presented to quantify evidence against the null hypothesis. Ethical approval was granted prior to the commencement of this study (NHS National Research Ethics Service Ref 04/Q1402/56).

Results

Overall Demographics

In total, 334 patients returned the SF-36 survey and 369 the QOL-2 survey, giving response rates of 67% and 74%, respectively. The mean age of respondents at time of surgery was 51.9 (SD 11.3) years for the SF-36 group and 52.5 (SD 11.2) years for the QOL-2 group. There was a female preponderance of 57% in both groups. The median tumour size for all responders was 1.5cm (IQR 1-2.5 cm). The median duration of follow-up was 8 years (mean 8.23 years, IQR 7-10 years).

There was no statistical evidence for differences in gender, tumour size or length of follow-up between responders and non-responders for either survey, nor in age for the SF-36 group. For age in the QOL-2 group, responders were found to be 3.8 (CI 1.5 – 6.2) years older than non-responders. This difference was found to be statistically significant ($p<0.05$) but not felt to be clinically important.

Short-Form 36 Survey Results

Table 1 shows the results of the short-form 36 (SF-36) survey for each of the 8 domains: Overall physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role limitations due to emotional health (RE), and general mental health (MH). Component scores for total physical (TPCS) and mental health (TMCS) are also shown. Values for an age-matched UK population are shown for comparison.[6] Figure 1 presents a graphical comparison between means of the SF-36 scores from our study and an age-matched UK

population. T-tests were performed to examine the observed difference between means for each domain; the resulting p values are reported in figure 1. There was strong evidence that scores from this study differ from the UK normative values for all domains except for the 'Role Emotional', where there was no statistical evidence for the difference (p=0.1).

Tumours were categorised into groups according to tumour size (Table 2). Linear regression analysis was performed to look for an association between tumour size and the SF-36 total physical (TPCS) and mental (TMCS) component score domains, adjusting for age as a potential confounding factor (Table 3). A group of the smallest tumours, consisting of intra-canalicular and less than 1cm tumours (n=55), was used as the reference category. For the TMCS domain, a patient with tumour size of 4cm or over was likely to have 3.4 less score than a patient (of the same age) with a tumour of less than 1cm. There was some evidence supporting this effect (p = 0.037). There was little evidence for the effect of smaller tumour sizes on the TMCS score and no evidence for tumour size effect on the TPCS domain.

Table 4 shows the correlation coefficients between age and the SF-36 domains. Pearson correlation tests showed that statistically significant correlation was observed in several of the SF-36 domains; PF, RP, BP, VT, MH, TPCS and TMCS. In some domains, mainly the physical subscales, this was a negative correlation whereas in others, mainly the mental subscales, the correlation was positive; the correlation coefficients for the TPCS and TMCS were -0.26 and +0.26, respectively.

Effect of time elapsed since surgery on the SF-36 domain scores was investigated using linear regression models, taking into account both age and tumour size. Improvement in component scores for total mental health was associated with increased time since surgery (p=0.005). A patient was found to have 0.3 higher score of total mental health than a patient (from the same age and tumour size category) who underwent surgery one year later. There was no relationship between the physical subscales or the total physical component score and time since surgery.

Results of the generic post-operative survey (QOL-2)

When asked about the effect of the operation, a significant proportion of patients reported an improvement ('a lot' or 'a little' better) in their overall quality of life (24%) and overall health (20.4%) (Table 5).

Statistical analysis (Spearman's rank correlation test) showed a positive correlation between the SF-36 total physical component score and patients' self-assessment of overall quality of life (correlation 0.26, $p<0.01$) and overall health (correlation 0.5, $p<0.01$). This correlation was not seen between

these measures and the total mental component score (quality of life; correlation 0.01, p=0.91 and health; correlation -0.02, p=0.77).

Of the 318 respondents in employment at the time of the survey, 195 (61.3%) continued in the same employment following their surgery. A further 22 (6.9%) chose to change their job following surgery, and 48 (15.1%) chose to retire. Fifteen (4.7%) and 38 (11.9%) respondents, respectively, felt forced to change job or to retire for medical reasons as a direct result of their operation. Of 300 respondents who were car drivers prior to surgery, 253 (84%) continued driving normally after a break (duration not specified in this study). A further 29 (10%) continued driving but with limited ability; 11 (4%) chose and 7 (2%) respondents felt forced to give up driving altogether.

When asked about the effect of the operation on ability to continue with sports or hobbies, 153 of 351 respondents (44%) continued as before, after a break (unspecified duration). A further 111 (32%) continued with ability limited a little and 39 (11%) with ability limited a lot. Forty-eight (14%) respondents chose to (7%) or felt forced to (7%) give up their previous sports or hobbies.

Seventy of 361 respondents (19%) reported feeling more positive following surgery. A further 133 (37%) had no change in their mood; 92(25%) and 37 (10%) reported feeling occasionally or frequently anxious or low in mood, respectively. Twenty-nine (8%) had felt depressed or required treatment for low mood/ depression. The response to this question correlated strongly with the SF-36 mental health subscale (correlation score =0.2) and total mental component score (correlation score = 0.23). Spearman's rank correlation tests showed that these results were statistically significant ($P<0.01$) in both cases.

Based on the senior author's previous anecdotal experience of post-operative reports from vestibular schwannoma patients, respondents were asked to report their experience of unusual or vivid dreams or nightmares. Of the 364 respondents, 55 (15%) could not recall and 181 (50%) had not experienced vivid dreams or nightmares. These were experienced, however, by 59 (16%) respondents for a few days, by 36 (10%) for a few weeks and by 33 (9%) for months or years after surgery.

When asked to report how their actual experience of their operation and recovery compared with their expectation, 160 of 361 (44%) respondents reported a better experience than expected, 58 (16%) the same as expected and 143 (40%) worse than expected.

Respondents were asked to grade their pre- and post-operative symptoms according to how much they affected daily life (washing, dressing, going out, work, housework etc.) both before and after

surgery. These results are summarised in table 6 as a cross-tabulation of pre- and post-operative results to show how the number of patients experiencing each symptom changed following surgery.

Discussion

Quality of Life

We present the results of a quality of life (QOL) survey of 500 patients who had undergone translabyrinthine excision of vestibular schwannoma, representing one of the largest single-surgeon experiences reported to date. To assess long-term post-operative QOL, the Short-Form 36 (SF-36) tool was selected. The SF-36 has been validated for use in QOL assessment and utilised for many diseases. It has the advantage of being comparable with published general population norms as well as with other studies of vestibular schwannoma surgery (Table 7).[4,7-19] We supplemented the SF-36 with additional disease-specific questions relating to vestibular schwannoma treatment.

This study found that all 8 of the domains of the SF-36, as well as the 2 component scores, were reduced following vestibular schwannoma surgery compared to the general population. This has been reported previously.[15] Other studies have found lower SF-36 outcomes in multiple (but not all) domains.[13,16,17,19,20] Interestingly, as in our study, some authors have found a particularly significant reduction in post-operative social functioning.[18,21] Cheng et al showed a QOL comparable to the normal population in 7 of 8 SF-36 domains.[10] Conversely, one prospective study of 15 patients undergoing microsurgery reported improved post-operative QOL at six months compared to pre-operatively and in comparison with age- and sex-matched norms.[22]

Studies of larger tumours (>3cm) have shown a reduction in quality of life when compared to the general population both before and immediately following surgery.[7,9,14] In this group, an improvement in QOL over time has been demonstrated.[7,23] Several published studies have found no relationship between tumour size and QOL outcomes.[8,10,20,24] Others have shown worse QOL outcomes in patients with larger tumours.[14,15,19] In a multivariate analysis, Carlson *et al.* found that large tumour size predicted the SF-36 mental component score.[25] Irving *et al.* found that quality of life, measured with the EORTC, did relate to tumour size when comparing small tumours to all tumours larger than 1.5cm, but found no difference between medium (1.5 to 2.5cm) and larger tumours.[26] Interestingly, patients with smaller tumours may experience a particularly noticeable deterioration in QOL even if the absolute reduction in QOL is less than that seen with larger tumours.[27] In our study, there was no correlation between the raw SF-36 scores and tumour size. Using linear regression to allow for age difference, however, patients with the largest tumours

(>4cm) were found to have a reduced mental component score (but not physical component score) compared to a reference group of those with the smallest tumours (1cm or less).

Several previous studies have shown better QOL outcomes in younger patients.[7,15] Conversely, others have found a trend towards improvement in post-operative QOL in older patients.[14,24] Others have shown that age had no effect on QOL.[10,26,27] In our series, there was a negative correlation between age and the physical subscales of the SF-36 (such that advancing age was associated with reduced QOL) but a positive correlation with the mental subscales. Carlson *et al.* also found that advancing age correlated with the physical but not the mental components of the SF-36.[25] Brooker *et al.* reported a similar relationship between the SF-12 (short version of the SF-36) and physical components, but no relationship with the mental components.[28] Other studies have found no correlation between age and mental components of the SF-36 and a variable relationship with the physical.[17,19,20,29] This could reflect the fact that older patients might be expected to be more susceptible to physical impairments. Conversely, older patients may be expected to have more realistic expectations of outcomes, more stable careers, better financial reserves and more developed coping strategies, thereby potentially improving their mental component scores.[24] We also found that the mental component score correlated with the time elapsed since surgery, after adjusting for age and tumour size, possibly suggesting improved coping strategies and adaptation over time.

When a reduction in post-operative QOL is identified, it is of course difficult to quantify how much it relates to the disease process itself, and how much to the treatment. Studies have demonstrated reduced SF-36 scores compared with a matched population following diagnosis, prior to any treatment.[22,29,30] This suggests that reduced post-operative QOL relates in part to the disease process, explaining why some studies have failed to show a significant difference in QOL between the three treatment modalities of watchful waiting, radiation treatment and surgical treatment.[4,23] The effect of the disease on QOL may be related to symptoms from the disease, and treatment may rarely be advocated in order to resolve symptoms e.g. intractable vertigo.[13] The psychological impact of a diagnosis of vestibular schwannoma is well recognised; the impact of anxiety about the diagnosis or disease progression on QOL must be considered when deciding on an individual's treatment.[4,31]

Despite the overall drop in SF-36 QOL scores, this study found that 24% and 20.4% reported a subjective improvement in overall quality of life and overall health, respectively. Subjective improvement in QOL has been reported previously; in one series of 42 vestibular schwannomas, 67% patients evaluated their health status as unchanged and more reported an improvement (21%) than

a deterioration (12%) despite a reduction in overall SF-36 scores.[16] Others have postulated that patients having surgery may have a greater sense of definitive treatment than those being observed.[23] Older patients may be anxious about the possibility of requiring future surgery when they may be less fit.[32] Browne *et al*. reported that 81% of vestibular schwannoma patients experienced at least one positive benefit following diagnosis and treatment.[11] Lifestyle changes made through choice rather than necessity may have a positive impact on QOL. For example, a patient who chooses to retire might notice an improved QOL despite any new post-operative physical or mental problems. In this study, 61.3% continued in the same job, with 22% and 16.6%, respectively, choosing to or feeling forced to change job or retire. Previous studies have reported similar outcomes.[14,15,17,19,33] We found that patients' subjective change in mood correlated strongly with the SF-36 mental health subscale. Whilst 37% reported no change in mood, a significant proportion (19%) reported feeling more positive. More importantly, 25% felt occasionally, and 10% frequently, anxious or low. Depression was experienced and/or required treatment in 8%. The potential psychological impact of vestibular schwannoma treatment, the importance of appropriate counselling and support and the need for new psychological outcome measures are well recognised.[11,14,30,33-36] In this study, 60% of respondents described their overall experience of surgery 'about the same' or 'better' than expected and 40% 'worse than expected'. This further highlights the need for optimal pre-operative counselling and post-operative support. Previous UK studies have drawn attention to patients' dissatisfaction with community services, with the majority feeling unsupported.[36,37]

Symptoms

The incidence of post-operative symptoms reported in this study are similar to those reported previously, including in surveys of national Acoustic Neuroma Associations; hearing loss, balance problems, tinnitus, facial weakness, headache and eye problems being the commonest complaints.[9,11,19,37-39] As hearing loss is a necessity in translabyrinthine cases, it is unsurprising that in our study the effect of hearing loss on daily life was improvement in only 6.6% post-operatively and was most commonly unchanged (54.4%).

Factors other than hearing loss are often found to have a greater impact on QOL; hearing preservation may not be associated with an improved QOL outcome.[21] The exception is the devastating impact on social integration arising from bilateral hearing loss, as reported in our department's prior study of patients with neurofibromatosis type 2.[40] Nonetheless, several studies have found imbalance and/or headache to have a greater effect on post-operative QOL than hearing loss or facial weakness.[17,19,25,38] Episodic vertigo is recognised as being particularly detrimental to

QOL in both treated and conservatively managed patients.[13,41-43] Conversely, some patients will continue a nearly normal life despite a severe facial palsy.[9,44]

Facial weakness is unsurprisingly most common in patients with larger tumours, and tends to have a greater impact on QOL in females.[45] Dry eyes relating to facial weakness, though rarely reported, are not uncommon for those with larger tumours. Rameh & Magnan reported that 36% of post-operative patients were 'mildly bothered' and 21.3% 'very bothered' by dry eyes; similar to our report of 24.2% of patients with a mild effect on daily activities and 33.2% with a moderate to severe effect from eye symptoms.[9]

In this study, vivid dreams or nightmares were experienced by 35% of 364 respondents. The senior author (RTR) had noticed patients reporting this occurrence and has previously reported recurrent dream-like, usually frightening, multi-coloured visual and tactile hallucinations in the initial post-operative period in 53% of patients following vestibular schwannoma surgery, compared to 17% of patients undergoing posterior fossa brain surgery.[46] Although the mechanism of such phenomena is unknown, hypnagogic hallucinations secondary to pontine vascular insufficiency has been hypothesised.[46] To our knowledge this is the first report of such symptoms affecting sleep for a prolonged period following vestibular schwannoma surgery.

The methodological drawbacks in this study include the potential for recall bias when retrospectively assessing patients' views on their surgical treatment. This may be minimised to some extent by the large number of patients who responded to the survey and the demographic similarity between responders and non-responders. Objective assessment of symptoms (e.g. self-assessment of facial nerve function) was not attempted as previous studies have demonstrated a poor correlation with clinical assessment.[19] In this study we used the SF-36 tool as a measure of generic post-operative QOL. The SF-36 is the most commonly used tool for this purpose, allowing comparison between studies, though the differences in patient populations and study design make direct comparisons difficult (Table 7).[4,7-19] There are certainly drawbacks to using the SF-36 due to its failure to assess many of the specific issues relevant to vestibular schwannoma treatment.[2] As in other published studies, we allowed for this by including additional, disease-specific questionnaire items. In this study, it was not possible to enquire about the details of some aspects of patients' outcomes e.g. questions concerning 'return to work' or 'sports and hobbies' did not differentiate between active and sedentary activities. Whilst unlikely to alter the conclusions of the study, differences in these areas would be interesting to observe. With the increased interest in QOL outcomes, it is likely that future vestibular schwannoma research will utilise disease-specific tools as well as both pre- and post-operative QOL assessments.[1,2,25,47]

Conclusion

In this survey of 500 patients undergoing translabyrinthine surgery for vestibular schwannoma under a single surgeon, post-operative QOL measured with the SF-36 was found to be significantly lower than that of the general UK population. Despite this fact, nearly a quarter of patients reported a subjective improvement in their QOL. This reflects the complicated nature of both quality of life measurement and the multi-faceted effect of the diagnosis and treatment of vestibular schwannoma for an individual patient. Tumour size was found to have an effect only on the mental component score of the SF-36 for tumours larger than 4cm. Increased age at time of surgery was associated with a reduction in the physical component of QOL and an improved mental component, the latter also improving with time following surgery. Our report of pre- and post-operative symptoms was in line with previously published studies, and highlights the importance of assessing post-operative headache and imbalance as well as hearing loss and facial function.

Quality of life outcomes are an important measure for patients undergoing treatment of vestibular schwannoma, the management of which is becoming increasingly complicated as the number of available treatment protocols grows. Generic and disease-specific tools should be a routine part of the assessment of vestibular schwannoma patients. Patients requiring surgery can then be accurately counselled about the likely outcomes, balanced against the potentially serious consequences of their vestibular schwannoma if untreated.

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Legends for Figures

Figure 1. Graphical comparison of SF-36 scores in this study with UK normative data

Appendix 1. Post-operative survey (referred to in text as QOL-2)

In general, how has your *overall quality of life* changed, if at all, as a result of the operation?*
In general, how has your *overall health* changed, if at all, as a result of the operation?*
What was your occupation *before* the operation?*
What effect, if any, did your operation have on your ability to continue working?*
What effect, if any, did your operation have on your ability to drive a car?*
What effect, if any, did your operation have on your ability to continue with sports or hobbies?*
What effect, if any, has the operation had on your overall mood?*
Following the operation, did you notice any unusual or vivid dreams or nightmares?*
How did your actual experience of the operation and recovery compare to what you expected?*
Please tell us which of the following symptoms you had *before* and *after* the operation, and how much they affected your daily life (washing, dressing, going out, housework etc.)†

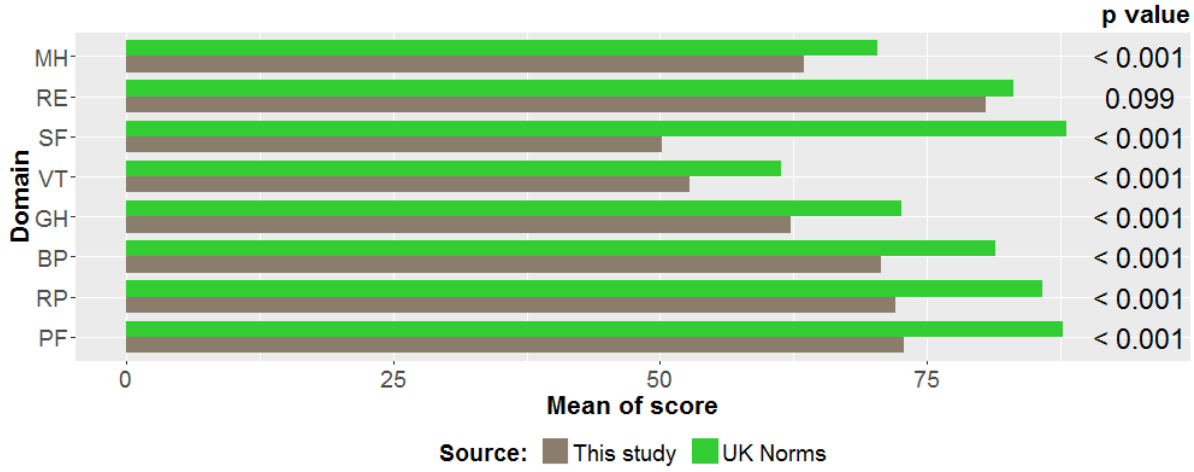
- Loss of hearing
- Tinnitus (ringing in the ears)
- Loss of balance
- Headache/ earache
- Facial weakness
- Eye problems (as a result of facial weakness)
- Other (please specify)

* Subject asked to select from five point Likert scale with appropriate options depending on the question (see text)

† Subject asked to select from options: none; mild (noticed but not concerned); moderate (bothered but continue with daily life); severe (a frequent or constant problem. Affects daily life or sleep)

Figure (TIFF, PDF, Word Doc, PPT, or EPS files are acceptable)

Broomfield et al Figure 1



Table

Broomfield et al Tables

Table 1. SF-36 scores for study respondents (n= 334) and comparison with UK normative data.

	This study (Mean, SD)	This study (Median, IQR)	UK Norms (Mean, SD)	Difference
PF	72.86 (29.06)	85 (55-95)	87.8	-14.9
RP	72.13 (31.43)	81 (50-100)	85.8	-13.7
BP	70.75 (28.59)	74 (51-100)	81.5	-10.8
GH	62.25 (25.50)	67 (42-82)	72.7	-10.5
VT	52.81 (11.11)	50 (50-56)	61.4	-8.6
SF	50.14 (9.90)	50 (50-50)	88.1	-38.0
RE	80.50 (28.74)	100 (75-100)	83.1	-2.6
MH	63.49 (10.44)	65 (60-70)	70.4	-6.9
TPCS	47.68 (12.65)	50.4 (40.3 – 58.2)	-	-
TMCS	42.38 (6.61)	42.4 (39.0 – 45.8)	-	-

PF - physical functioning, RP - role limitations due to physical health, BP - bodily pain, GH - general health, VT – vitality, SF - social functioning, RE - role limitations due to emotional health, MH - general mental health, TPCS - total physical component score, TMCS - total mental component score.

Table 2. Distribution of tumour sizes (n=334).

Tumour Size	n= (%)
Intracanalicular	26 (7.8)
<1cm	29 (8.7)
1cm<2cm	119 (35.6)
2cm<3cm	75 (22.5)
3cm<4cm	45 (13.5)
>=4cm	23 (6.9)
Data missing	17 (5.1)

Table 3. Estimated effects of tumour sizes on the TPCS and TMCS SF-36 domains using linear regression analysis adjusted for age.

SF-36 Domain	Tumour Size							
	1cm < 2cm		2cm <3cm		3cm <4cm		>= 4cm	
	Effect (95% CI)	*P value*	*Effect (95% CI)*	*P value*	*Effect (95% CI)*	*P value*	*Effect (95% CI)*	*P value*
TPCS	0.7 (-3.3,4.7)	0.743	-0.4 (-4.8,3.9)	0.840	-0.6 (-5.5,4.3)	0.811	1.5 (-4.8,7.7)	0.644
TMCS	-1.8 (-3.8,0.3)	0.096	-1.2 (-3.5,1.1)	0.295	-2.5 (-5.0,0.1)	0.056	-3.4 (-6.6,-0.2)	**0.037**

TPCS - total physical component score, TMCS - total mental component score.

Table 4. Relationship between age at time of surgery and SF-36 scores.

	PF	RP	BP	GH	VT	SF	RE	MH	TPCS	TMCS
Correlation	-0.29	-0.2	-0.16	-0.06	0.16	0.04	0.48	0.13	-0.26	0.26
P Value	<0.01	<0.01	<0.01	0.25	<0.01	0.53	0.48	0.02	<0.01	<0.01

PF - physical functioning, RP - role limitations due to physical health, BP - bodily pain, GH - general health, VT – vitality, SF - social functioning, RE - role limitations due to emotional health, MH - general mental health, TPCS - total physical component score, TMCS - total mental component score.

Table 5. Self-report of effect of surgery on overall quality of life and overall health

(n=, %)	A lot better	A little better	Unchanged	A little worse	A lot worse
Overall QOL (n=369)	62 (16.8)	26 (7.0)	100 (27.1)	138 (37.4)	43 (11.7)
Overall health (n=367)	48 (13.1)	27 (7.4)	140 (38.1)	112 (30.5)	40 (10.9)

QOL – Quality of Life

Table 6. Self-grading of pre- and post-operative symptoms with regards to their effect on daily activities. Boxes indicate number of patients.

Pre-operative		Post-operative													
			None	Mild	Mod.	Severe	NA	Total		None	Mild	Mod.	Severe	NA	Total
	Change in Hearing	None	5	3	13	16	1	38	Tinnitus†	98	15	18	10	6	147
		Mild	3	7	55	30	3	98		10	43	21	8	5	87
		Mod.	1	6	96	74	2	179		9	16	44	9	2	80
		Sever	3	0	10	29	1	43		3	3	7	29	0	42
		NA	1	1	2	5	2	11		3	2	1	1	6	13
		Total	13	17	176	154	9	369		123	79	91	57	19	369
	Loss of balance	None	39	45	31	13	2	130	Headache/earache	142	19	19	5	11	196
		Mild	5	23	27	12	3	70		23	28	4	4	1	60
		Mod.	9	28	56	12	1	106		21	11	17	13	2	64
		Sever	5	12	8	22	1	48		7	11	8	5	1	32
		NA	1	4	3	2	5	15		5	0	0	1	11	17
		Total	59	112	125	61	12	369		198	69	48	28	26	369
	Facial weakness	None	123	52	57	29	5	266	Eye problems†	139	64	53	35	7	298
		Mild	10	27	9	3	1	50		4	14	3	2	1	24
		Mod.	4	6	12	3	1	26		3	5	13	2	2	25
		Sever	0	3	2	2	1	8		0	0	1	5	1	7
		NA	4	5	1	1	8	19		3	3	0	2	7	15
		Total	141	93	81	38	16	369		149	86	70	46	18	369

NA – Not answered

† Tinnitus was further defined as ‘ringing in the ears’. Eye problems were defined as those specifically related to facial weakness.

Table

Table 7. Comparison of published SF-36 scores with present study in patients following surgical management of acoustic neuroma

	This Study		Carlson *et al* [4]	Turel *et al* [7]	Scheich *et al* [8]	Rameh *et al* [9]	Cheng *et al* [10]	Browne *et al* [11]	Pollock *et al* [12]	Godefroy *et al* [13]	Nicoucar *et al* [14]	Tufarelli *et al* [15]	Bauman n *et al* [16]	Betchen *et al* [17]	Kelleher *et al* [18]	Martin *et al* [19]
Year	2016		2015	2015	2014	2010	2009	2008	2007	2007	2006	2006	2005	2003	2002	2001
QOL tool	SF-36		SF-36	SF-36	SF-36	SF-36	SF-36	SF-36	HSQ	SF-36	SF-36	SF-36	SF-36	SF-36	SF-36	SF-36
Region of Study	UK		US/ Norway	India	Germ-any	France	Austr-alia	New Zealand	USA	Holland	Switzer-land	Italy	Germ-any	USA	UK	UK
Surgery route	TL		All	SO	MF	TL*, RS	TL, RS	Most TL	All	TL	RS	All	MF	TL, SO	NS	TL
N=	334		144	100	86	59	98	85	36		72	386	42	101	19	76
Age (years)	51.9		Mean 58 (SD NS)	Mean 44.2 (SD 11.5)	Mean 53.5 (11.7)	Mean 55.2 (SD 11.4)	Mean 55 (SD NS)	Mean 59 (SD 11.0)	Mean 48.2 (SD NS)	Mean 55.9 (41-69)	Mean 50.8 (SD NS)	Mean 49.4 (SD 12.1)	Median 57	Mean 52 (23-79)	Median 44.1	Mean 52 (16-74)
Tumour size (cm)	Median 1.5 (IQR1-2.5)		<= 3 (Mean NS)	Mean 4.2 (3 – 6.6)	Stage I and II	>2 Stage III/ IV	Mean 2.2 (SD NS)		Mean 1.4 (excl. IC)	IC Patients had severe vertigo	Stage III/ IV	14% IC 40% 0.1-1.5 46%>1.5	27% <1 73% >1		Average NS	Mean 2.5 (SD NS) (0.5-5.5)
Follow-up (months/ years)	Median 8yrs (IQR 7-10)		Mean 7.7 yrs (SD NS)	NS	>6mo	Mean 5.9yrs (SD 2.0)	>6 mo	6.9yrs (SD 5.7)	>12mo	12	Mean 7.6yrs (6-228mo)	Mean 4yrs (SD 2.4)	Median 3.1yrs (range 1-5.3)	>6mo	36.8mo (14-176mo)	Mean 18mo
SF-36 Subscale	Mean (SD)	Median (IQR)	Mean (SD NS)	Mean (SD)	Mean (SD NS)	Mean (SD)	Mean (SD)	Mean (SD NS)	Mean (SD)		Mean (SD NS)	Mean (SD)	Median (IQR)	Mean (SD NS)	Mean (SD NS)	Median (IQR)
PF	72.86 (29.06)	85 (55-95)	-	69.6 (24.6)	72.7	78.2 (24.8)	76.2 (28.1)	78.8	87.1 (16.8)	77.1 (12.8)	-	77.8 (27.7)	82.5 (65-91.2)	82.5	77.6	73 (45-95)
RP	72.13 (31.43)	81 (50-100)	-	48.5 (38.7)	62.3	49.2 (42.6)	63.8 (43.7)	67.8	81.2 (30.4)	70.6 (20.2)	56.6	66.7 (40.6)	87.5 (0 -100)	71.7	57.9	25 (0-100)
BP	70.75 (28.59)	74 (51-100)	-	68.3 (23.3)	75.1	87.3 (25.2)	74.3 (26.5)	77.9	76.2 (24.1)	69.7 (22.7)	72.5	67.9 (25.1)	74 (48.7 - 100)	60.5	77.2	84 (61-100)
GH	62.25 (25.50)	67 (42-82)	-	63 (21.6)	57.1	58.9 (21.0)	67.1 (25.6)	73.8	70.9 (20.3)	70.6 (13.7)	68.2	60.6 (25.5)	61 (38.7 – 77)	71.3	68.6	77 (41-87)
VT	52.81 (11.11)	50 (50-56)	-	61 (18.9)	50.2	51.1 (19.0)	61.4 (22.9)	65.6	60.8 (19.0)	62.1 (17.0)	55.1	55.1 (23.9)	55 (33.7-80)	63.8	60.3	48 (35-65)
SF	50.14 (9.90)	50 (50-50)	-	70.6 (24.7)	71.4	76.7 (28.6)	78.4 (27.9)	86.6	85.1 (22.2)	79.4 (17.1)	65.8	73.2 (25.4)	81.2 (62.5 - 100)	79.8	68.8	75 (38-100)
RE	80.50 (28.74)	100 (75-100)	-	54.8 (43)	62.8	59.3 (49.5)	77.6 (35.1)	73.9	92.2 (22.6)	72.5 (29.4)	67.1	67.7 (41.4)	100 (0-100)	73.9	75.4	100 (33-100)
MH	63.49	65	-	68.7 (19.6)	64.7	55.9 (23.7)	75.5 (19.3)	63.2	76.1 (15.9)	72.9 (19.6)	66.8	61.7 (26.9)	74 (56-80)	71.5	67.2	72 (56-88)

	(10.44)	(60-70)														
TPCS	47.68 (12.65)	50.4 (40.3 – 58.2)	49	-	-	-	-	-	49.2 (8.2)	-	-	-	-	-	-	-
TMCS	42.38 (6.61)	42.4 (39.0 – 45.8)	51	-	-	-	-	-	51.6 (8.1)	-	-	-	-	-	-	-

QOL – Quality of Life, HSQ – Health Status Questionnaire (modified SF-36)

TL – Translabyrinthine, RS – Retrosigmoid, MF – Middle cranial fossa, SO – Suboccipital, IC - Intracanalicular

SD – Standard deviation, IQR – Interquartile range

NS – Not specified

* - SF-36 data shown only for patients operated with the translabyrinthine approach, for more direct comparison